Centrum Rzeczoznawstwa Budowlanego

Inżynieria Bezpieczeństwa Obiektów Antropogenicznych 3 (2021) 11-20
https://inzynieriabezpieczenstwa.com.pl/

Inżynieria Bezpieczeństwa Obiektów Antropogenicznych

Life cycle engineering of a construction object

Jerzy OBOLEWICZ*[1] and Adam BARYŁKA[1]

[1]Scientific Institute of Engineering of the Safety of Anthropogenic Objects, Warsaw, Poland

Abstract

Building objects are anthropogenic objects that are born - planning, arise - design, develop - build and die - are demolished or modernized at the end of their lives. In this way, they create a life cycle in which human needs in the field of broadly understood construction are met.The article presents the use of engineering for the analysis and assessment of the construction life cycle.

"The essence of engineering object construction is the procedure leading to the creation of a safe object throughout its life cycle."

Keywords: construction, building structures, facility life cycle, engineering

1 Introduction

The term "engineering" has long been used in science and technology to describe issues related to the analysis, study and design of anthropogenic objects. Anthropogenic objects are objects that have been generated by humans to meet their needs. Over the years, this term has evolved historically and with the development of civilization, and has gained more and more importance. Its scope and content also changed.

Currently, this concept is most often used to describe a procedure in which the analysis of a selected fragment of reality is conducted comprehensively using a process approach, and the proposed concepts and solutions are formulated in a systemic perspective, e.g. to solve material problems [2], ecological [15] or construction problems [3]. Building objects are anthropogenic objects (buildings, structures and small architecture objects) located in a specific environment that meet human needs in the field of broadly understood construction .

The Act - Construction Law [21] regulates activities covering the design, construction, maintenance and demolition of buildings and defines the rules of operation of public administration bodies in these areas. The building structure as a whole and its individual parts, together with the related construction equipment, should be designed and built in a manner specified in the regulations, including technical and construction regulations, and in accordance with the principles of technical knowledge, taking into account the expected service life, ensuring:

- compliance with the basic requirements for construction works specified in EU regulations [14] concerning:
  - load capacity and stability of the structure,
  - fire safety,
  - hygiene, health and the environment,
  - safety of use and availability of facilities,
  - protection against noise,
  - energy savings and thermal insulation,
  - sustainable use of natural resources,
- conditions of use consistent with the purpose of the facility, in particular in terms of:

*Corresponding author: E-mail address: obolewiczjerzy@gmail.com (Jerzy OBOLEWICZ)

https://dx.doi.org/10.37105/iboa.115
Received 1 July 2021
Available online 15 September 2021
ISSN 2450-1859, eISSN 2450-8721
Published by Centrum Rzeczoznawstwa Budowlanego

  - water and electricity supply and, as needed, heat and fuels, assuming the effective use of these factors,
  - disposal of sewage, rainwater and waste,
  - the possibility of access to telecommunications services, in particular in the field of broadband Internet access,
- ability to maintain proper technical condition,
- necessary conditions for the use of public utility facilities and multi-family housing by disabled people:
- conditions of occupational health and safety,
- civil protection, in line with the requirements of civil defense,
- protection of objects entered in the register of monuments and objects under conservation protection,
- appropriate location on the building plot,
- respecting the legitimate interests of third parties in the area of impact of the facility, including ensuring access to a public road
- safety and health protection conditions for people on the construction site.

The building object should be used in a manner consistent with its intended use and the requirements of environmental protection and maintained in a proper technical and aesthetic condition, preventing excessive deterioration of its functional properties and technical efficiency.

In new buildings and existing buildings undergoing reconstruction or projects aimed at improving energy efficiency within the meaning of the provisions on energy efficiency, which are used by public finance sector entities within the meaning of the provisions on public finance, it is recommended to use devices that use energy generated from renewable energy sources and enable the production of energy from such sources, as well as technologies aimed at the construction of buildings with high energy performance [1]. In the case of construction works consisting in thermal insulation of a building, covering more than 25% of the surface of the external partitions of this building, the minimum requirements for energy efficiency and thermal protection provided for in the technical and construction regulations for the reconstruction of the building must be met.

The Construction Law [15] is supplemented by the Public Procurement Law [17], in which the legislator defined the product life cycle as any possible subsequent or related phases of the subject of delivery, service or construction work, in particular: research, development, industrial design, testing, production, transportation, use, repair, modernization, alteration, life-long maintenance, logistics, training, wear, demolition, decommissioning and disposal. This term clearly shows that the interest should include not only the implementation of the subject of the contract itself, perceived as the final result, but also the phases of the project leading to this implementation, e.g. analysis, research, design or subsequent phases, e.g. operation, withdrawal from use and disposal. It is also important to define the required characteristics of materials, products or services that can be included in the description of the subject of the contract, in particular:

- ensuring accessibility for people with disabilities,
- requirements concerning:
  - specific levels of environmental and climate impact,
  - for a certificate of conformity or a declaration of conformity,
  - with specified capacity, safety or dimensions, including quality assurance procedures,
  - with specific terminology, symbols, tests and testing methods,
  - specific packaging and labeling,about the instructions for use,
  - production processes and methods at each stage of the life cycle of building objects,
  - additional examinations and tests carried out by authorized bodies concerning conformity assessment and market surveillance [5],
  - specific rules for designing and costing,
  - conditions for testing, inspection and acceptance of construction objects,

  - about construction methods and techniques,
  - any other technical conditions.

  The costs assumed for selecting the best offer have still not been clearly defined. The contracting authority is free to apply this criterion and select the type of costs that will determine the selection of the offer. The cost criterion can be determined using life cycle costing. Life Cycle Costing covers the costs of:

- incurred by the contracting authority or other users related to:
  - about the acquisition,
  - about use, in particular consumption of energy and other resources,
  - about maintenance,
  - on decommissioning, in particular collection and recycling costs,
- attributed to environmental externalities related to the life cycle of a product, service or works, relating to: emissions of greenhouse gases and other pollutants, and others related to climate change mitigation, as long as their monetary value can be determined and verified.

2 Construction investment process

All construction investments start with an idea, followed by the planning of the investment process, design, implementation, handover of the completed construction project for operation and use of the building object. This entire process is often referred to as the life cycle of a building object. The life cycle of a building object is a set of well-thought-out, harmonized process activities, including technical, technological, organizational, legal and financial activities, which are aimed at the safe implementation and operation of a building object with specific financial resources and in a fixed time (Table 1).

The life cycle of a building object as a process is divided into two main areas:

- area A - construction investment process in which a virtual building object is created,
- area B - operational investment process in which there is a real building object.

The life of a building object presented in the model (Fig. 1) consists of four stages and nine phases. After the investor has made a decision about the form of the facility, which will be the result of the project (Area A, stage I), technical, economic and analytical studies of the feasibility of the project are carried out in terms of technical, economic and environmental conditions (stage 1). They concern the conditions for the implementation of the project on the construction site and the operation of the building structure. On this basis, a concept is prepared and a project for the implementation of the project is developed, including the construction design (phase 2) and preparation of the project for implementation (phase 3). The building object does not exist in area A. Jet is a virtual object that is transformed during construction into a real building object (stage II, stage 4) and a used object (stage III, stage 5, 6) until the decision to liquidate is made (stage IV, stage 7, 8, 9).) or a decision to modernize it.

The participants of the process, each in their own scope, are responsible for actions taken in individual areas, stages and phases. The provisions of the Construction Law [21] define in detail the scope of rights and obligations as well as the responsibilities of individual participants in the construction process. Each of them, excluding the investor, must have appropriate theoretical and practical preparation of their technical skills. The confirmation document is the possession of building qualifications in a given field. In addition, construction supervision authorities control the proper performance of the tasks of each participant in the construction process, as well as its proper course. Within the meaning of the Act, the participants in the construction process are: the investor, construction manager or works manager, designer, investor's supervision inspector. Each of them, depending on the position held, uses the knowledge necessary to manage and direct people, which influence the behavior of other participants [5, 16].

3 Investor

It is the investor's responsibility to organize the entire construction process, while taking into account the safety and health protection rules contained in the regulations [21]. In particular, it must ensure:

Table 1. Areas, stages, phases, activities occurring in the life cycle of a building object [4, 6],

No.	**Process area**	**Process step**	**Process phase**	**Activities involved in the process**
1	A. Construction investment process	I. Preparatory work for the investment project	Formulating the project	1. Justification for the purposefulness of the investment. 2. Choice of investment location. 3. Determining variants and scope of investment implementation. 4. Feasibility study of the selected variant. 5. Determining the basic design assumptions and the decisionto prepare the documentation.
2.			Projects	1. Environmental impact assessment of a construction investment. 2. Obtaining development conditions and ownership rights. 3. Designer's selection - tender and contract. Preparation of project documentation. Obtaining permits and arrangements. Development of the investor's cost estimate. 4. Obtaining a building permit or notification of construction works
3.			Works prior to the commencement of construction works	1. election of the works contractor - tender and contract. 2. Preparation of the construction site and its delivery to the contractor. 3. Implementation of the BIOZ plan and notification of the date of commencement of works. 4. Obtaining a construction log.
4.		II. Execution of works construction	Construction of a building object	1. Conducting construction works. Partial acceptance. Final acceptance. 2. Development of as-built documentation. 3. Notification of completion of construction. 4. Obtaining an occupancy permit.
5.	B. Operation investment process	III . Use of the building object	Accession to use	1. Getting started. 2. Keeping operational documentation of the building object.
6.			Maintaining the facility	1. Assessment of the technical condition of the facility. Periodic inspections and their documentation. 2. Current and capital repairs. Development of the scope of renovation works and the sequence of their execution. 3. Remedial actions for the safe use of the facility.
7.		IV. Building decommissioning	Building object diagnostics	1. Assessment of damage to building structure elements resulting from natural wear, external factors, random events.
8.			Demolition of a building object	1. In the event of failure to meet the technical and utility requirements for the facilities, make a decision on demolition. 2. Preparation of documentation of demolition works. 3. Conducting the demolition of the facility. 4. Preparation of an environmental impact report. 5. Completion of the exploitation of the investment.

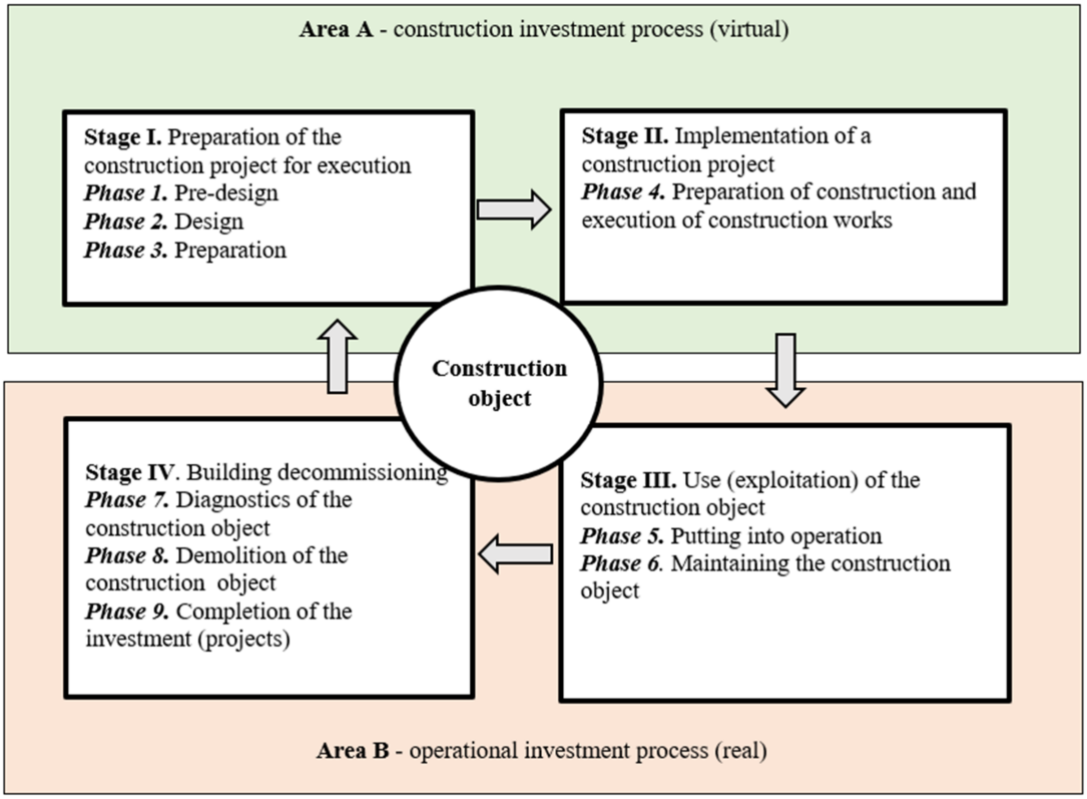

Figure 1. Model of the life cycle of a building object [4, 6].

- development of a construction design, as well as, if necessary, other projects,
- taking over the construction management by the construction manager,
- development of a health and safety plan,
- execution and acceptance of construction works,
- in cases justified by a high degree of complexity of construction works or ground conditions, supervision of construction works - by persons with appropriate professional qualifications.

The investor has the right to appoint an investor's supervision inspector on the construction site, as well as to appoint a designer to exercise author's supervision. Unless the competent authority, in the building permit decision, imposed on the investor an obligation to appoint an investor's supervision inspector and to ensure author's supervision. Such an obligation is imposed in two cases, namely when it is justified:

- high degree of complexity of the facility or construction works,
- the expected environmental impact of the facility or construction work.

Types of objects for the implementation of which it is required to appoint an investor's supervision inspector, as well as a list of construction objects and technical criteria (which should be followed by the authority when imposing on the investor the obligation to appoint an investor's supervision inspector [12].

4 Investor's supervision inspector

The main duties of the investor's supervision inspector include [21]:

- representing the investor on the construction site by controlling the compliance of its implementation with the design and building permit, regulations and rules of technical knowledge,

- performed works and built-in construction products, in particular preventing the use of defective products and products not approved for use in construction; quality checking.
- checking and acceptance of construction works subject to covering or disappearing, participation in tests and technical acceptance of installations, technical devices and chimney ducts, as well as preparation and participation in the acceptance of ready-made building objects and handing them over for use,
- confirmation of actually performed works and removal of defects, as well as - at the investor's request - control of construction settlements.

The investor's supervision inspector has the right to issue orders to the construction manager or construction works manager confirmed by an entry in the construction log. He may also require the construction manager or the works manager to make corrections or redo defective works, suspend construction works in the event of a threat in their further performance or cause non-compliance with the design or building permit.

The investor appoints one chief investor's supervision inspector as the coordinator in the case of construction of a building which requires the appointment of investor's supervision inspectors in various specialties.

5 Designer

The basic duties of a designer include [21]:

- development of the construction design in a manner consistent with the provisions of the decision on building conditions and land development, in the decision on environmental conditions or in the permit [20], as well as in accordance with the requirements of the act, regulations [19] and the principles of technical knowledge,
- ensuring the participation of people who have construction qualifications to design in the relevant specialization in the development of the project and mutual technical coordination of design studies prepared by these people, ensuring that the principles contained in the safety and health protection regulations are taken into account in the construction process, taking into account the specificity of the designed building,
- preparation of information on safety and health protection, taking into account the specificity of the designed building, included in the safety and health protection plan,
- obtaining the required arrangements, opinions and verification of design solutions in the scope resulting from the regulations,
- explaining doubts about the project and its solutions,
- producing or agreeing on individual technical documentation referred to in the act on construction products,
- exercising the author's supervision designated by the investor or the competent authority in the scope
  - ascertaining the compliance of implementation with the design during the performance of construction works,
  - agreeing on the possibility of introducing changes in relation to those provided for in the design, reported by the construction manager or the investor's supervision inspector,
- ensuring that the architectural and construction design is verified in terms of compliance with the regulations, including technical and construction regulations, by a person with construction qualifications to design without restrictions in the relevant specialty or by a construction expert. This obligation does not apply to:
  - the scope covered by the opinion on the basis of specific regulations, e.g. fire, sanitary, health and safety issues,
  - designs of building facilities with simple structure, such as: single-family residential buildings, small farm, livestock and storage facilities.

The designer, as well as the person checking the architectural and construction design, always attaches to the design a statement on the preparation of a construction design in accordance with applicable regulations and the principles of technical knowledge.

During the construction works, the designer has the right to enter the construction site and make entries in the construction log book regarding its implementation. It may also require an entry in the construction log to suspend construction works in the event of a possible threat or their performance contrary to the design.

6 Site manager or works manager

The main responsibilities of the site manager include:

- the protocol takeover and appropriate protection of the construction site along with the building objects, devices and fixed points of the geodetic network, as well as being under the protection of elements of the natural and cultural environment,
- keeping construction documentation,
- providing the delimitation of the object by a surveyor and organizing the construction and managing it, in a manner consistent with the design and building permit, regulations, as well as occupational health and safety regulations,
- coordinating the implementation of tasks preventing threats to safety and health protection,
- coordinating activities leading to compliance with the safety and health protection rules contained in the regulations and in the safety and health protection plan during the execution of construction works,
- to introduce necessary changes resulting from the progress of construction works in the information on safety and health protection and in the safety and health protection plan,
- taking appropriate steps to prevent unauthorized access to the construction site,
- stopping construction works, in the event of identifying the possibility of a hazard, and immediate notification of the competent authority,
- notifying the investor about an entry in the construction log regarding the suspension of construction works due to their non-compliance with the design,
- implementing the recommendations entered in the construction log,
- reporting to the investor for inspection or acceptance of works that are covered or disappearing, and to ensure that, required by law or stipulated in the contract, tests and checks of installations, technical devices and chimney pipes are performed, before the building object is reported for acceptance,
- preparation of as-built documentation for a building object,
- reporting the acceptance of the building object with an appropriate entry in the construction log and participation in the acceptance activities and ensuring the removal of the identified defects, as well as providing the investor with a declaration of compliance of the execution of the building object with the construction design and building permit conditions and regulations, as well as restoration of the proper condition and order of the construction site and - if used - road, street, adjacent property, building or premises [21].

The construction manager has the right to apply to the investor for changes in the designs if they are justified by increasing the safety of construction works or improving the construction process. He may also comment on the recommendations contained in the construction logbook. It should be absolutely remembered that it is forbidden to combine the functions of the construction manager and the investor's supervision inspector. This is due to the nature of both of these functions. The supervision inspector's task is primarily to perform supervisory activities, also in relation to the construction manager. The combination of these functions would make it impossible to carry out effective and objective control of the entire construction process.

Prior to the commencement of construction, the site manager is obliged to prepare or commission a safety and health protection plan, taking into account the specific nature of the building and the conditions for conducting construction works, including the planned simultaneous conduct of construction works and industrial production [21].

Requirements for safety and health protection in the performance of the above construction works are covered by separate regulations in this regard.

7 Responsibilities of the owner or manager of the building object

According to the Construction Law, the owner or manager of a building is obliged to use it in a manner consistent with its intended use, environmental protection requirements and to maintain it in a proper technical and aesthetic condition, preventing excessive deterioration of its functional properties and technical efficiency, ensuring in particular that the so-called basic requirements, i.e .:

- construction safety,
- fire safety,
- operational safety,
- appropriate hygiene and health conditions,
- environmental protection, protection against noise and vibration,
- energy savings and adequate thermal insulation of partitions.

In addition, the owner or manager of the building is obliged to ensure, with due diligence, the safe use of the facility in the event of external factors affecting the facility, related to human activity or natural forces, such as: lightning, seismic shocks, strong winds, intense precipitation, landslides, ice phenomena on rivers and the sea, lakes and water reservoirs, fires or floods resulting in damage to a building object or a direct threat of such damage, which may endanger human life or health, property safety or the environment [6, 7]. Basic obligations related to:

- maintaining and using the facility in accordance with its intended purpose [13],
- respecting the requirements of environmental protection,
- maintaining the facility in a proper technical condition,
- maintaining the facility in a proper aesthetic condition,
- keeping a construction book,
- carrying out technical inspections.

The inspection of a building object should be understood as an ongoing inspection of the technical condition of buildings and fixed technical devices, combined with the removal of minor defects and damage, replacement of worn parts and adjustment of mechanisms [13]. Any damage found during the inspection, which the operating personnel and maintenance technicians are not able to remove, should be immediately reported to the immediate supervisor. In addition, the inspection should be carried out each time after heavy rains, storms, hurricanes.

The following types of reviews are distinguished:

- *Operational inspections* are carried out by the personnel operating the devices and maintenance technicians. The results of the inspection should be recorded in the device operation book,

- *Periodic inspections* should be carried out in annual and five-year cycles.

Periodic inspection, at least once a year, consists in checking the technical condition of:

- building elements, structures and installations exposed to harmful weather conditions and damaging effects of factors occurring during the use of the facility,
- installations and devices for environmental protection, gas installations and chimneys: smoke, exhaust and ventilation [11].

The inspections include the following checks:

- checks to be made at least once a year,

- control of installations and devices for environmental protection,

- checking the technical condition of chimney pipes (smoke, exhaust and ventilation),

- inspection of gas installations [11],

- checks to be made at least every 5 years, including:

- control of the technical condition of the facility,
- for the control of cooling devices,
- for safe use control,
- for inspections made every two years,
- for boiler inspections,
- one-time inspection of the heating system with the boiler.

The competent authority may - in the event of finding inadequate technical condition of the building or its part, which may cause a threat; life or health of people, safety of property, the environment - order to carry out an inspection at any time, as well as request the presentation of an expert opinion on the technical condition of the facility or its part.

Certain rules apply to the inspection of the technical condition [18]. The inspections should be carried out by persons with building qualifications in the relevant specialties. The technical condition of electrical and lightning protection installations should be inspected by persons with qualifications required for supervision over the operation of devices, installations and power networks.

The technical condition of chimney pipes should be inspected by persons who have the qualifications of a chimney sweep master in relation to smoke and gravity exhaust and ventilation ducts.

The person conducting the inspection of the technical condition of the facility (annual or five-year inspection) draws up an inspection report, which includes information on the technical condition of individual structural and finishing elements of the facility as well as post-inspection recommendations. Pursuant to the provisions of the Construction Law Act [21], the owner, manager or user of the facility (who is responsible for repairs) are required to remove the identified damage and to supplement any deficiencies that could endanger human life or health, and the safety of property or the environment. This should take place immediately after the inspection.

Pursuant to the Act [21], there is an obligation to perform appropriate construction works, the purpose of which is to bring the construction structure to a proper technical condition, by operation of law. The person inspecting the facility states this obligation in the inspection report.

8 Analysis of the life cycle of a building object

The analysis of the life cycle of a building object is aimed at assessing the hazards associated with a building object in individual areas, stages or phases of the cycle or activities, both by identifying and quantitatively and qualitatively assessing the materials and energy used as well as waste introduced into the environment, and assessing the impact of these materials. , energy and waste to the environment. The price analysis and evaluation covers the entire life span of the building object.

The LCA (Life Cycle Assessment) technique can be used for the assessment. The LCA technique directs research on the impact of a building object on the environment in the area of ecosystem, human health, used resources or broadly understood safety. Impact assessment can be performed for both the product and the function. LCA is regarded as a "cradle to grave analysis". The principles of the LCA technique are described in international standards, which were introduced by the Polish Committee for Standardization to Polish Standards [8–10].

The LCA technique is one of the most methodically advanced tools for ecological design [9]. It is widely used in economic practice. It can be combined with other life cycle techniques [10], e.g. LCC (Life Cycle Costing) or Social Life Cycle Assessment (SLCA) and can be an excellent tool for analyzing the life cycle of a building.

References

1. Baryłka, A. & Obolewicz, J. Empirical veryfication of worksafety evoution. *Modern Engineering* **3,** 125–130 (2020).
2. Grabski, M. *Istota inżynierii materiałowej* (Politechnika Warszawska, Grabkowo, 2000).
3. Kasprowicz, T. Podstawowe problemy i zakres badań inżynierii przedsięwzięć budowlanych. *Inżynieria Morska i Geotechnika* **5** (2013).

4. Obolewicz, J. *Demoskopia bezpieczeństwa pracy i ochrony zdrowia przedsięwzięć budowlanych,* (Oficyna Wydawnicza Politechniki Białostockiej, Białystok, 2018).
5. Obolewicz, J. & Szlendak, J. *Podstawy organizacji, zarządzania i pracy kierowniczej* (Wydawnictwo Wszechnicy Mazurskiej w Olecku, Olecko, 2002).
6. Obolewicz, J., Baryłka, A., Jaros, H. & Ginda, G. A map of knowledge and its importance in the life cycle of a constructiom object. *Inżynieria Bezpieczeństwa Obiektów Antropogenicznych* **2** (2020).
7. Obolewicz, J., Baryłka, A., Szczerbak, M. & Cesarz, K. The knowledge map as a management tool for the perception of occupational health and safety for construction facul tiles students. *Inżynieria Bezpieczeństwa Obiektów Antropogenicznych* **1** (15-28 2021).
8. *PKN-ISO/TR 14047:2006 Zarządzanie środowiskowe – Ocena wpływu cyklu życia – Przykłady stosowania ISO 14042*
9. *PN-EN ISO 14040:2009 Zarządzanie środowiskowe – Ocena cyklu życia – Zasady i struktura*
10. *PN-EN ISO 14044:2009 Zarządzanie środowiskowe – Ocena cyklu życia – Wymagania i wytyczne*
11. *PN-M.-34507:2002 Instalacja gazowa. Kontrola okresowa* (2002).
12. *Rozporządzenie Ministra Infrastruktury z dnia 19 listopada 2001 r. w sprawie rodzajów obiektów budowlanych, przy których realizacji jest wymagane ustanowienie inspektora nadzoru inwestorskiego*
13. *Rozporządzenie Ministra Spraw Wewnętrznych i Administracji z dnia 16 sierpnia 1999 r. w sprawie warunków technicznych użytkowania budynków mieszkalnych*
14. *Rozporządzenie Parlamentu Europejskiego i Rady (UE) Nr 305/2011 z dnia 9 marca 2011 r. ustanawiającego zharmonizowane warunki wprowadzania do obrotu wyrobów budowlanych i uchylającego dyrektywę Rady 89/106/EWG*
15. Siuta, J. Istota i zadania inżynierii Ekologicznej (eko-inżynierii). *Inżynieria Ekologiczna – Ecological Engineering* **46** (2016).
16. Szlendak, J. & Obolewicz, J. *Podstawy zarządzania i zachowań organizacyjnych* (Wydawnictwo Wszechnicy Mazurskiej w Olecku, Olecko, 2005).
17. *Ustawa z dnia 11 września 2019 r. Prawo zamówień publicznych*
18. *Ustawa z dnia 13 kwietnia 2016 r. o systemach oceny zgodności i nadzoru rynku*
19. *Ustawa z dnia 15 grudnia 2000 r. o samorządach zawodowych architektów, inżynierów budownictwa oraz urbanistów*
20. *Ustawa z dnia 21 marca 1991 r. o obszarach morskich Rzeczypospolitej Polskiej i administracji morskiej*
21. *Ustawa z dnia 7 lipca 1994 r. Prawo budowlane*